

Surface Decontamination and Biofilm Eradication using Focused Microwave Energy

Completed Technology Project (2010 - 2013)



Project Introduction

Future long duration missions to Mars and beyond will bring new challenges to the health and well-being of astronauts. Potential medical issues due to infection and contamination can become more serious and likely to occur the longer crewmembers are away from Earth. Decontamination is a concern due to increased virulence of microbes and up mass launch restrictions (i.e., disinfectants/reagents, clean clothes, hardware components). Bacteria can accumulate on surfaces and in exercise clothing causing limited usage and bad odors. Therefore, nonchemical waterless cleansing and deodorizing capability alternatives are needed to meet the stringent up mass requirements for space exploration. In addition, biofilms are particularly difficult to eradicate due to their significantly enhanced resistance. To address microbial contamination for spacecrafts and habitats; (i.e., interior surfaces, dirty exercise clothes, NOMEX, towels, EVA spacesuit undergarment cooling systems, water systems and components), focused microwave energy will be assessed to determine its efficacy for bacteria/biofilm eradication in these critical problem areas.

This project will assess focused microwave energy at specific frequencies to target and kill bacteria and biofilm in three critical problem areas:

1. Bacteria present on surfaces for a variety of housekeeping activities/applications on the International Space Station (ISS) and future, next generation spacecraft and habitats
2. Biofilms (bacteria growing in colonies) which are highly resistant and currently very difficult to eliminate
3. Astronaut clothing and towels. Used exercise clothes cause bad odors on ISS and are currently discarded after approximately two to three weeks resulting in significant costs due to up mass. Nonchemical and non/low water consuming alternatives are needed to solve these issues while reducing astronaut exposure to harmful chemicals.

Effectively sterilizing surfaces using microwave energy could provide a means to eradicate microbes, thereby preventing the spread of infection (preventive medicine), improving system functionality/longevity of components, and enhancing function of water systems by reducing/eliminating microbial contaminants and biofilms. Presently, NASA has no effective means to eradicate biofilms inside tubing of circulating water systems (astronaut undergarment thermal cooling system) or the ability to clean astronaut clothing with no water/detergents during spaceflight. This dual-use technology has the potential for not only being a viable approach for astronaut hygiene, housekeeping and laundry for extended missions (>1 year) but also as a means to effectively eradicate biofilms in medical devices.

Radio frequencies in the Ka-band (microwave) range are preferentially absorbed by dielectric materials (i.e. bacteria) where it is converted to heat, leading to death of the bacteria. Characterizing exposure conditions to optimize bacteria kill in biofilm is nontrivial and is a function of bacterial



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species' sensitivities, microwave emitter power and frequency, antenna design and emitting surface area, target proximity, and time of exposure. This proposal is expected to establish the protocols (exposure requirements and dose responses of biological relevance) for using microwave energy to effectively sterilize and eliminate bacteria/biofilm contamination.

Anticipated Benefits

This project supports the critical need for an effective, light weight, portable, multiuse system that can disinfect: 1) surfaces; 2) astronaut clothing; 3) EVA suit undergarment cooling systems and; 4) water systems and components without the need for resupply (i.e., disinfectants/reagents, clean clothes/undergarments, components and spare parts - preventative maintenance). Astronaut hygiene including surface decontamination and dirty laundry (i.e., exercise clothes, towels) is a concern due to potential increased virulence of microbes and up mass restrictions. Bacteria accumulates in astronaut exercise clothes causing limited usage and bad odors. Exercise clothes are currently discarded on ISS after approximately two to three weeks resulting in significant costs to NASA due to up mass. Nonchemical and non/low water consuming alternatives are needed on ISS to solve these problems and reduce astronaut exposure to harmful chemicals. In addition, biofilms are particularly difficult to eradicate due to their enhanced resistance and may be potentially even more in microgravity. Sterilizing surfaces using microwave energy will eradicate microbes, thereby preventing the spread of infection (preventive medicine), damage to equipment due to microbial growth, and enhance function of water systems by reducing/eliminating microbial contaminants and biofilms. A prototype device could be built and flight certified for validation on ISS in preparation for final implementation on a future asteroid or Mars mission.

This project supports the critical need for an effective, light weight, portable, multiuse system that can disinfect: 1) surfaces; 2) astronaut clothing; 3) EVA suit undergarment cooling systems; and 4) water systems and components without the need for resupply of water and disinfectants/reagents. Surface decontamination is a critical issue for future space exploration (i.e., next generation spacecraft, habitats) due to potential increased virulence of microbes in microgravity and up mass restrictions. Bacteria also accumulates in astronaut exercise clothes causing limited usage and bad odors. Exercise clothes are currently discarded on ISS after approximately two to three weeks resulting in significant costs to NASA due to up mass. Nonchemical and non/low water consuming alternatives are needed to solve these problems while reducing astronaut exposure to harmful chemicals within the confined space environment. Future exploration missions will not have access to resupplies (clean clothes, towels, disinfectants) and will have to make use of available onboard resources for extended periods of time. In addition, biofilms are particularly difficult to eradicate due to their enhanced resistance and may be potentially even more in microgravity. Sterilizing surfaces using microwave

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Center Innovation Fund: JSC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Carlos H Westhelle

Project Manager:

Diane L Byerly

Principal Investigator:

Diane L Byerly

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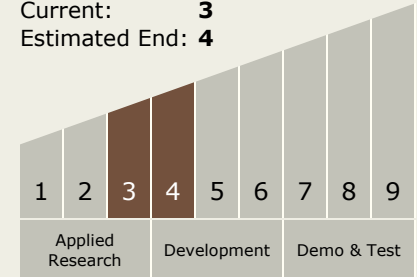


energy will eradicate microbes, thereby preventing the spread of infection (preventive medicine), damage to equipment due to microbial growth, and enhance function of water systems by reducing/eliminating microbial contaminants and biofilms. A prototype device could be built and flight certified for validation on ISS in preparation for final development, integration and implementation for future exploration missions.

This project supports the critical need for an effective, light weight, portable multiuse system that can disinfect: 1) surfaces; 2) astronaut clothing; 3) undergarment cooling systems; and 4) water systems and components without the need for resupply of water and disinfectants/reagents. Decontamination is a critical issue for future and commercial space exploration (i.e., next generation commercial spacecraft, habitats) due to potential increased virulence of microbes in microgravity and up mass restrictions. Exercise clothes are currently discarded after approximately two to three weeks on ISS resulting in significant costs to NASA due to up mass. Nonchemical and non/low water consuming alternatives are needed to solve these problems while reducing exposure to harmful chemicals within the space environment. In addition, biofilms are particularly difficult to eradicate due to their significantly enhanced resistance and may be potentially even more in microgravity. Sterilizing surfaces using microwave energy will eradicate microbes, thereby preventing the spread of infection (preventive medicine), damage to equipment from microbial growth, and enhance function of water systems by reducing/eliminating microbial contaminants and biofilms. This device could be built and flight certified for commercial use for next generation spacecraft and habitats once the prototype is validated on ISS. The commercial space industry could benefit and use this technology as well as NASA.

Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **4**



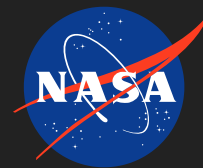
Technology Areas

Primary:

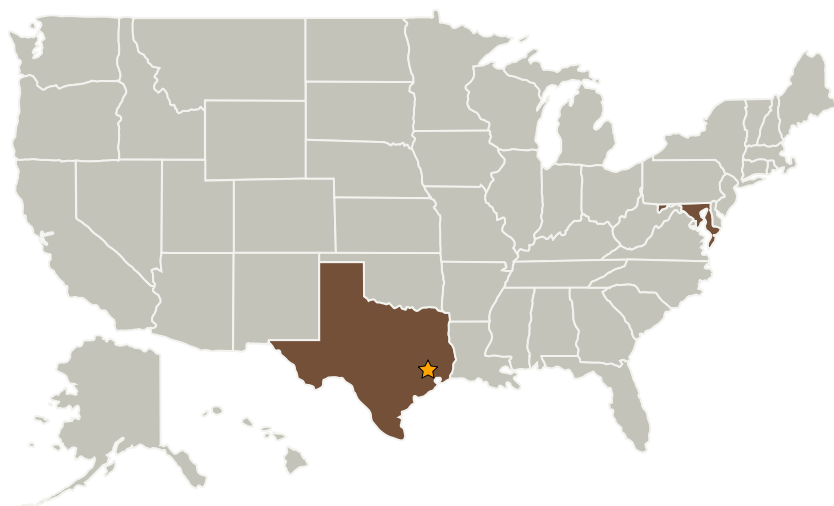
- TX06 Human Health, Life Support, and Habitation Systems
 - └ TX06.4 Environmental Monitoring, Safety, and Emergency Response
 - └ TX06.4.4 Remediation

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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Johnson Space Center (JSC)	Lead Organization	NASA Center	Houston, Texas
Jacobs Engineering Group, Inc.	Supporting Organization	Industry	Dallas, Texas
Wyle Integrated Science and Engineering Group	Supporting Organization	Industry	

Co-Funding Partners	Type	Location
BioMat Sciences, Bethesda, MD	Industry Veteran-Owned Small Business (VOSB)	
Houston Methodist Hospital	Industry	
Notre Dame of Maryland University	Academia	Baltimore, Maryland

Primary U.S. Work Locations	
Maryland	Texas

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Links

Patent Link 1
(no url provided)